IS 11726 (1985): Requirements for instruments for measuring vibration severity of rotating and reciprocating machines [MED 28: Mechanical Vibration and Shock]

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(Reaffirmed 2002)

Indian Standard

REQUIREMENTS FOR INSTRUMENTS FOR MEASURING VIBRATION SEVERITY OF ROTATING AND RECIPROCATING MACHINES

(ISO Title : Mechanical Vibration of Rotating and Reciprocating Machinery — Requirements for Instruments for Measuring Vibration Severity

Engineering Standards Sectional Committee, EDC 1 [Ref : Doc : EDC 1 (4635)]

National Foreword

This Indian Standard is identical with ISO 2954-1975 'Mechanical vibration of rotating and reciprocating machinery — Requirements for instruments for measuring vibration severity' issued by the International Organization for Standardization (ISO) was adopted by the Indian Standards Institution on the recommendation of Engineering Standards Sectional Committee and approval of the Mechanical Engineering Division Council.

In the adopted standard certain terminology and conventions are not identical with those used in Indian Standards; attention is specially drawn to the following:

Comma (,) has been used as a decimal marker while in Indian Standards the current practice is to use point (.) as the decimal marker.

Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

Cross Reference

International Standard	*Corresponding Indian Standard*
ISO 2041-1975	IS : 11717 - 1985 Vocabulary on vibration and shock (Identical)
ISO 2372-1974	IS : 11724 - 1985 Basis for specifying the rules in evaluating the mechanical vibration of machines in the operating range 10 to 200 rev/s (Identical)
ISO 2373-1974	IS : 11725 - 1985 Measurement and evaluation of vibration severity of certain rotating electrical machinery with shaft height between 80 and 400 mm (Identical)

There are no Indian Standards corresponding to IEC Pub 184 - 1965 and IEC Pub 222 - 1966 to which reference has been made in **2**.

Adopted 2 September 1985 Gr 4

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1 SCOPE AND FIELD OF APPLICATION

This International Standard states the requirements which a measuring instrument for vibration severity of machines should meet if inaccuracies of measurement, particularly when making comparisons between one machine and another, are not to exceed a specific value. Instruments meeting the requirements of this International Standard are suitable for use in carrying out the procedures specified in ISO 2372 and ISO 2373 and are designated "Measuring instruments for vibration severity in rotating and reciprocating machines".

The instruments covered by this International Standard give direct indication or recording of root-mean-square vibration velocity, which is defined as the measuring unit of the vibration severity.

NOTES

1 A method of checking true root-mean-square indication is described in an annex.

2 Subject to limitation of the measuring-frequency range, these instruments may be used for other applications where similar accuracy of measurement is required, for example measurement of vibration velocity of structures, tunnels, bridges, etc.

2 DEFINITIONS

The terms used in this International Standard are defined in the following IEC Publications and ISO International Standards :

IEC 184, *Methods for specifying the characteristics of electromechanical transducers for shock and vibration measurements.*

IEC 222, *Methods for specifying the characteristics of auxiliary equipment for shock and vibration measurement.*

ISO 2041, *Vibration and shock – Vocabulary.*

ISO 2372, *Mechanical vibration of machines with operating speeds from 10 to 200 rev/s – Basis for specifying evaluation standards.*

ISO 2373, *Mechanical vibration of certain rotating electrical machinery with shaft heights between 80 and 400 mm – Measurement and evaluation of the vibration severity.*

3 GENERAL REQUIREMENTS

A vibration measuring instrument usually consists of : a vibration pickup; an indicator set which contains an amplifier, correcting filter networks for the frequency response and an indicating or recording instrument; and a power supply system.

The requirements described in this clause apply to the general characteristics of the complete assembly of the pickup and the true v_{rms} indicator set. Clauses 4 and 5 contain the detailed requirements for each of these main units.

3.1 The frequency range of the vibration severity measuring instrument shall be from 10 to 1 000 Hz.

NOTE – This means that the frequency range corresponds to the frequency interval employed in the evaluation scale in ISO 2372.

3.2 The sensitivity within the measuring-frequency range shall not deviate from the reference sensitivity at 80 Hz by more than the quantities given in the table.

TABLE – **Sensitivity relative to the reference sensitivity at 80 Hz and limiting values of the permissible deviation within the frequency interval from 1 to 10 000 Hz**

Frequency Hz	Relative sensitivity		
	Nominal value	Minimum value	Maximum value
1	–	–	0,01
2,5	0,016	0,01	0,025
10	1,0	0,8	1,1
20	1,0	0,9	1,1
40	1,0	0,9	1,1
80	1,0	1,0	1,0
160	1,0	0,9	1,1
500	1,0	0,9	1,1
1 000	1,0	0,8	1,1
4 000	0,016	0,01	0,025
10 000	–	–	0,01

To minimize measurement errors caused by the interference due to vibrations with frequencies outside the measuring-frequency range, the sensitivity shall decrease

rapidly in a clearly defined manner at the limits of the frequency range. Both the required nominal values of the sensitivity and the permissible minimum and maximum values are given in the table.

To preclude doubts about the course of the sensitivity between the cutoff frequencies shown in the table, figure 1 illustrates the course of the nominal value of the relative sensitivity and the limit of the permissible deviation within the whole frequency range from 1 to 10 000 Hz.

NOTE — In some cases it may be necessary to limit further the measuring-frequency range at its upper or lower boundaries to avoid interfering vibrations which are irrelevant to the assessment of the vibration characteristics of a machine. For this purpose the instrument may be equipped with additional high-pass or low-pass filters. It is recommended that the cutoff frequencies and edge steepness of these filters be selected in accordance with IEC specifications.

When the measuring-frequency range is narrowed down by additional filters, the measured value should not be used for assessing the vibration severity in accordance with ISO 2372 and ISO 2373. To avoid errors, it is necessary to state the cutoff frequencies for the measuring-frequency range as well as the measured value, for example v_{rms} (40 to 100 Hz) = 7,5 mm/s.

3.3 The selection of the measurement range shall be such that the indication of the lowest level of the vibration severity to be measured shall be equal to at least 30 % of the full-scale value. The minimum and maximum levels of the vibration severity range (for example in accordance with table 1 of ISO 2372) shall be stated, for example "Measuring instrument for vibration severity with measurement range 0,28 to 28 mm/s".

3.4 The error of the vibration severity measuring instrument is composed of the permissible deviations for the frequency response in accordance with 3.2 and the error in the absolute value of the sensitivity at the reference frequency of 80 Hz (i.e. calibration error). The measurement error may be up to a maximum of ± 10 % of the indicated value, including the calibration error, at 80 % of full-scale value.

These limits of error apply over the whole operating temperature range authorized for the vibration pickup and indicator set (see 4.8 and 5.4), for all types of attachments to the vibration pickup (see clause 4), for all lengths of connecting cable between the vibration pickup and the indicator provided by the manufacturer (see 4.14) and a ± 10 % fluctuation in the supply voltage.

NOTE — Only one of the above parameters shall be checked at a time.

3.5 For calibration, the pickup shall be excited by a sinusoidal vibration with a vibration direction which deviates by not more than ± 5° from that of the sensitive axis of the pickup. The total harmonic distortion of the exciting vibration velocity shall not exceed 5 %. The velocity of the exciting vibration must be known with an uncertainty of less than ± 3 % within the whole measuring-frequency range.

It is recommended that the reference value of the sensitivity at 80 Hz be adjusted to v_{rms} = 100 mm/s at a room temperature of 20 ± 2 °C.

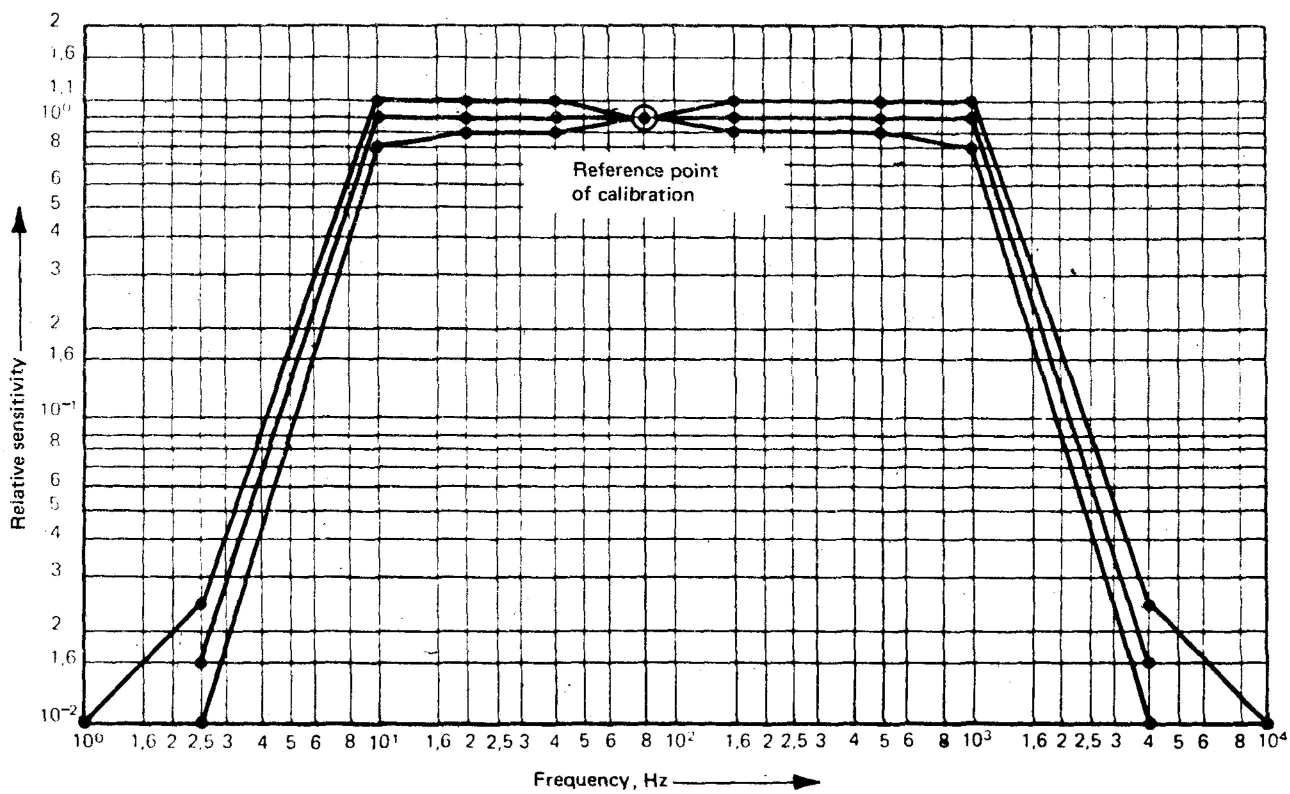

FIGURE 1 — **Nominal value of relative sensitivity and limits of permissible deviation**

4 REQUIREMENTS FOR THE VIBRATION PICKUP AND CONNECTING CABLE

4.1 The pickup shall be of the seismic type, i.e. it shall measure the vibrations of interest by comparison with a static reference system determined by the mode of operation of the pickup.

4.2 If a vibration pickup designed for attachment to the object of measurement is used, this shall be affixed by a rigid mechanical connection, for example cementing, clamping or screwing on or by means of a probe tip. No mechanical resonances of the rigid mechanical attachment or of the probe tip shall appear in the operating frequency band of the pickup.

4.3 For all types of attachment, the transverse sensitivity ratio shall be less than 0,1 over the whole measuring-frequency range.

The maximum level of vibration velocity for linear response of pickups shall be at least three times the vibration velocity at full-scale deflection in the sensitive direction.

4.4 To show the extent to which the vibration pickup affects the object of measurement, the effective mass of the vibration pickup shall be indicated in an easily visible manner on the vibration measuring instrument. To suit a wide range of applications, the mass shall be kept to the minimum possible.

NOTE — An indication of whether the mass of the pickup is too great can be obtained by the following method :
Double the co-vibrating mass of the pickup by an additional mass; if the new indication shows a deviation from the original reading of more than 12 %, the mass of the vibration pickup is too great as compared to the object of measurement and the result should be rejected.

4.5 The amplitude and frequency range of the vibration pickup shall be wide enough to avoid exceeding the permissible measurement error, as specified in 3.4.

4.6 The pickup shall withstand, without changing its characteristics, vibration in all directions of at least three times its specified maximum vibration input.

4.7 The equivalent input quantity of the self-interference by hum and noise and the equivalent input quantity of the extraneous interference for interference fields and excitations with a magnitude as stated below shall not affect the measurement by more than 10 %. When the value depends on the orientation of the instrument in the field, the most unfavourable value shall be used.

The manufacturer shall state the results of tests made under the following disturbing conditions :

4.7.1 The pickup shall be subjected to a homogeneous magnetic field of 100 A/m and 50 or 60 Hz and the field intensity shall be measured before inserting the pickup.

4.7.2 The pickup shall be subjected to a homogeneous airborne noise field with an rms sound pressure level of 100 dB re 2×10^{-5} Pa in each octave, produced by a random noise generator or a warble tone generator over the range 32 Hz to 2 kHz.

4.7.3 If the pickup has an electric conducting connection to the object of measurement and the indicator is line operated, an earth current of 100 mA rms at the supply frequency shall be fed into the earth connection of the pickup and discharge at the earth terminal of the indicator set.

4.8 The operating temperature range of the vibration pickup and connecting cable within which the error of measurement will not exceed the limiting values specified in 3.4 shall be stated.

4.9 The permissible temperature range to which the pickup and connecting cable can be subjected without damage shall be stated.

4.10 The *maximum non-operational vibration and shock* limits in any axis of the pickup to which it can be subjected without damage shall be stated.

4.11 The maximum humidity to which the pickup and connecting cable (as well as supplementary cables which are included) can be exposed and continue to operate within specification shall be stated.

If the pickup is to be used in any other hazardous environment such as corrosive atmosphere, the ability of the pickup to withstand this environment shall be indicated. If the pickup is to be used in an explosive atmosphere, its intrinsic safety shall be stated.

4.12 If applicable, the output of the pickup due to the base strain sensitivity at its mounting surface shall be indicated.

4.13 If available, information on the predicted mean time between failures, life expectancy and the recommended time between recalibrations of the pickup shall be given.

4.14 If there is a connecting cable between the vibration pickup and the indicator set, its length shall be at least 1 m. The manufacturer shall state what additional extension cables can be used without exceeding the tolerances in 4.7.

5 REQUIREMENTS FOR THE INDICATOR SET

5.1 The indicating instrument may be a pointer-type instrument, a graph recorder or a digital indicator.

5.1.1 The instrument shall indicate the true root-mean-square vibration velocity.

5.1.2 The error in calibration of the instrument shall not exceed ± 2,5 % of the full-scale value.

5.1.3 The indicator on the instrument shall be easily readable down to 1/5 of the full-scale value. To identify the quantity measured and the unit, "v_{rms} in mm/s" shall be marked on the instrument.

5.2 When a sinusoidal signal with a frequency anywnere within the measuring-frequency range and an amplitude permitting a steady-state nominal value of 70 % of the full-scale value is fed suddenly into the input of the indicator set at an equivalent voltage, the initial overshoot shall not be more than 10 % of the final reading. There shall be no undershoot at the time when the difference of the peak values of the pointer oscillations, as compared to the final position of the pointer, is a maximum of 1,5 % of the full-scale value.

5.3 For the purpose of checking the amplification, there shall be a device which permits a setting of the total amplification of the indicator at a specific frequency (for example, 50 Hz) with an uncertainty of less than ± 2 %.

5.4 The operating temperature range and non-operating temperature range of the indicator set shall be stated.

5.5 The maximum humidity to which the indicator set can be exposed and continue to operate within specification shall be stated.

If the indicator set is to be used in any other hazardous environment such as a corrosive atmosphere, the ability of the indicator set to withstand this environment shall be stated. If the indicator set is to be used in an explosive atmosphere, its intrinsic safety shall be stated.

6 POWER REQUIREMENTS

The input power requirements for the pickup and indicator set shall be specified.

ANNEX

METHOD FOR TESTING rms-VOLTAGE INDICATORS

A.1 TEST CIRCUIT

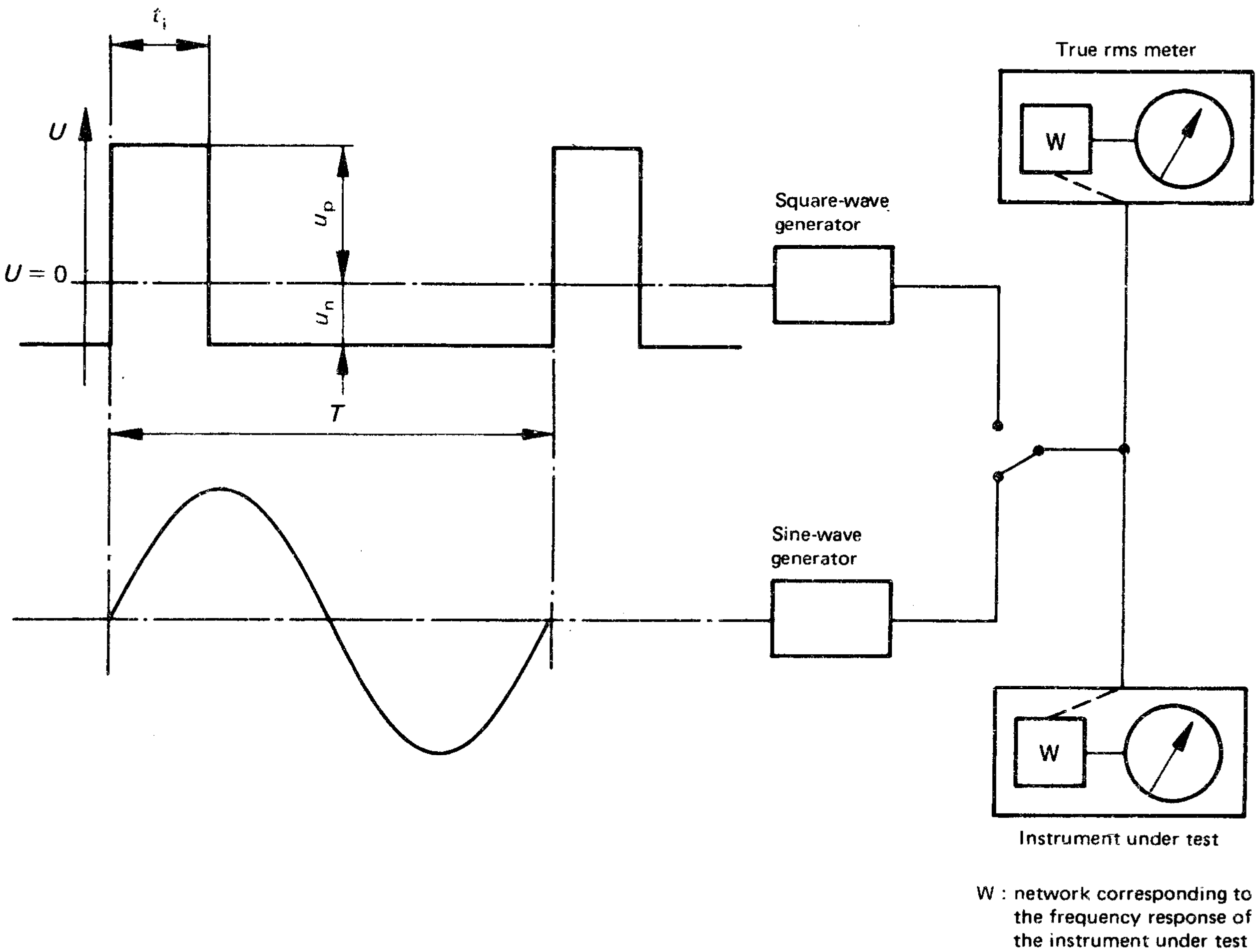

FIGURE 2 – **Circuit for the testing of rms-voltage indicators**

The following procedure is given as a method suitable for the testing of rms-voltage indicators. The values given below are based on the following definitions of crest factor :

$$\text{crest factor} = \frac{\hat{U}}{\bar{U}} \qquad \ldots (1)$$

where

$\hat{U}$ is the larger amplitude of the generalized rectangular asymmetrical wave in figure 2 (i.e. $\hat{U} = |u_p|$ or $|u_n|$, whichever is larger);

$\bar{U}$ is the root-mean-square value of the wave.

CREST FACTOR VALUES

By definition,

$$\bar{U} = \sqrt{\frac{1}{T} \int_0^T u^2 \, dt} \qquad \ldots (2)$$

For the general case shown in figure 2, it can be shown that

$$\bar{U} = \sqrt{u_n^2 + (u_p^2 - u_n^2)\left(\frac{t_i}{T}\right)} \qquad \ldots (3)$$

and that the

$$\text{crest factor} = \frac{\hat{U}}{\sqrt{u_n^2 + (u_p^2 - u_n^2)\left(\frac{t_i}{T}\right)}} \qquad \ldots (4)$$

Three special cases are

A) Symmetrical square wave : $\left(u_p = u_n \text{ and } t_i = \frac{T}{2}\right)$

$$\text{crest factor} = 1 \qquad \ldots (5)$$

B–1) Asymmetrical square wave : $\left(u_p > u_n \text{ and } t_i = \frac{T}{2}\right)$

$$\text{crest factor} = \sqrt{\frac{2}{1 + \left(\frac{u_n}{u_p}\right)^2}} \qquad \ldots (6)$$

B–2) Asymmetrical square wave : $\left(u_p < u_n \text{ and } t_i = \frac{T}{2}\right)$

$$\text{crest factor} = \sqrt{\frac{2}{1 + \left(\frac{u_p}{u_n}\right)^2}} \qquad \ldots (7)$$

C) rectangular-pulse wave : $(u_n = 0 \text{ and } t_i < T)$

$$\text{crest factor} = \sqrt{\frac{T}{t_i}} \qquad \ldots (8)$$

A.2 PROCEDURE

A.2.1 Adjust the square-wave generator for t_i to be 4 ms. Adjust the period for T of both generators to be 8 ms.

A.2.2 Adjust the sine-wave generator amplitude for a reading on the instrument under test to be approximately 90 % of the full scale value. Note the reading on the true rms meter.

A.2.3 Switch the circuit to the square-wave generator and adjust the amplitude to give the same indication as in A.2.2 on the instrument under test. Note the reading on the true rms meter.

A.2.4 Repeat the procedure of A.2.3 while varying the period of T from 8 to 40 ms.

A.2.5 The difference between the true rms readings for A.2.2 and A.2.3 shall not exceed 5 % of the full-scale value related to the instrument under test for all the values of T given in A.2.4.